THE NICKEL BULLETIN

A SUMMARY OF CURRENT INFORMATION ON NICKEL

JANUARY, 1954

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ABSTRACTS OF CURRENT PUBLISHED INFORMATION ON NICKEL AND ITS ALLOYS

GENERAL

Chemical Polishing: Review of Recent Developments

R. PINNER: 'Theory and Practice of Chemical Polishing. A Survey of Solutions and Processes for Various Applications.' *Electroplating*, 1953, vol. 6, Oct., Nov.; pp. 360–7, 401–10.

Part I deals mainly with solutions and methods for chemical polishing of copper-base alloys. The advantages of chemical polishing are discussed in comparison with effects producible by (1) electropolishing, or (2) polishing by mechanical methods. Details are given of various solutions which have been proposed for chemical polishing of copper alloys (including nickel silver), Monel, and nickel. A process which is important in this connexion is the one developed by Battelle Memorial Institute, in which a bath containing phosphoric, nitric and acetic acids is used, the proportions being varied according to the material treated. Details of operation are given, and the advantages and limitations of this procedure are discussed. A solution recently developed is more dilute: it contains phosphoric, nitric, and hydrochloric acids, with some other addition agents. This bath is claimed to have certain advantages over the Battelle solution, in that it can be operated at a lower temperature, is cheaper, more easily maintained, more efficient, insensitive to addition of water, less corrosive, and applicable to a wider range of material. Full details are given of operating conditions.

Part II covers processes for chemical polishing of aluminium and its alloys, iron and steel (including stainless steels), zinc and cadmium, and other metals (silver, lead, beryllium, zirconium). Later sections of Part II contain discussion of the metallographic applications of the chemical method of polishing; its use in superfinishing and shaping; procedure for regeneration of chemical-polishing baths, and the economics of this method of polishing vis-à-vis other processes. Comparative costs are quoted for typical brass components. The review is well documented.

A third article in the series, to be published later, will be concerned with the theory of chemical polishing.

See also—

R. PINNER: 'Theory of Electrolytic Polishing. A Review.' *ibid.*, Dec., pp. 444–50.

This paper has been interposed, in the series on chemical polishing, between the two parts dealing with practice and the final part on theory, since the mechanisms of chemical and electrolytic polishing have much in common. Considerable attention has already been given to the theoretical aspect of electrolytic polishing, and this review is supported by references to the major literature. The subject is dealt with in sections covering, respectively, liquid-film and solid-film theories: the factors influencing polishing and methods of evaluating polishing efficiency are also discussed.

High-Purity Metals: Source of Supply in U.K.

See abstract below.

Use of Perchloric Acid in Electrochemical Analysis

See abstract on p. 3.

NICKEL

High-Purity Metals: Source of Supply in U.K.

'Supply of Pure Metals.' *Bull. Inst. Metals*, 1953, vol. 2, p. 57.

In 1947 the Chemistry Research Board of the Department of Scientific and Industrial Research set up a Pure Metals Committee, to investigate the position with regard to the supply of metals in a high degree of purity and to initiate any work necessary to increase the availability or purity of such materials. The Committee has purchased, through the Director of the Chemical Research Laboratory, stocks of metals of a high standard of purity, either in the form of specially prepared batches or as a safeguard against the unforeseen disappearance of a particularly good grade of material from commercial production. The intention is that these stocks shall be available for urgent research purposes, at cost plus a small handling charge.

In the list given below, purity (per cent.) indicates the content of uncombined metals in the specimens. In

	Purity %		Purity %
Aluminium	99·99	Nickel	99·96+
Antimony	99·92	Niobium	99·7
Bismuth	99·97	Potassium	99·99+
Cadmium	99·99+	Rhenium	99·99
Cobalt	99·95	Silicon	99·93
Copper	99·99+	Sodium	99·99+
Gallium	99·98+	Tantalum	99·9+
Germanium	99·99+	Thallium	99·9+
Indium	99·993	Tin	99·99+
Iron	99·96	Titanium	99·92
Lead	99·99+	Vanadium	99·7
Lithium	99·98	Zinc	99·99+
Manganese	99·8*	Zirconium (+ hafnium)	99·75

* Remainder oxygen

most cases complete chemical analyses can be supplied, and the quantities available are on at least the pound scale.

Enquiries in connection with this stock should be addressed to the Secretary, Pure Metals Committee, Metallurgy Division, National Physical Laboratory, Teddington, Middlesex.

Use of Perchloric Acid in Electrochemical Analysis

G. NORWITZ: 'Use of Perchloric Acid in Electrochemical Analysis.' *Metallurgia*, 1953, vol. 48, pp. 257–8.

After discussion of the use of perchloric acid in electrolysis with the mercury cathode, a survey is made of the rôle of this acid in estimation of specific metals: bismuth, cadmium, cobalt, copper, lead, nickel, silver, tin, zinc. References to original literature are given and the essential features of analytical procedure for determination of each element are outlined.

'*Nickel.* Nickel can be precipitated with dimethylglyoxime or with sodium hydroxide and bromine, the precipitate and filter paper dissolved in a mixture of sulphuric, perchloric and nitric acids, and the solution evaporated to fumes of sulphuric acid. The nickel can then be deposited from an ammoniacal solution in the usual manner. The perchloric acid must be driven off, because of the precipitation of an insoluble purple salt, nickel ammonium perchlorate.'

Precipitation of Nickel Oxalate

J. A. ALLEN: 'The Precipitation of Nickel Oxalate.' *Jnl. Physical Chemistry*, 1953, vol. 57, Oct., pp. 715–16.

Rate of formation of precipitates of nickel oxalate in solutions containing nickel sulphate and oxalic acid were studied by turbidimetric and dilatometric techniques which cover successive stages of the reaction. Equations were derived relating the rate of formation to the initial concentrations of nickel sulphate and oxalic acid in the solution. A mechanism based on the formation and subsequent re-arrangement of a complex is suggested. The work described is part of a general study of the properties of the oxalates of divalent heavy metals in the solid state.

Chemical Polishing: Review of Recent Developments

See abstract on p. 2.

ELECTRODEPOSITION AND OTHER COATING METHODS

Cleaning of Metals for Electroplating: Evaluation of Degreasing Tests

H. B. LINFORD and E. B. SAUBESTRE: 'Cleaning and Preparation of Metals for Electroplating. VII. Final Summary on Degreasing Evaluation Tests.' *Plating*, 1953, vol. 40, Nov., pp. 1269–71.

This is the final report under A.E.S. Research Project No. 12, in which methods of cleaning and criteria for evaluating cleanness of surface have been studied. The *bibliography* attached to this summary review includes reference to all reports in the series issued under this Project.

A critical consideration of the requirements which should be satisfied by a cleaner-evaluation test, and of the sensitivity of the various types of test examined during this research, has led the authors to development of a new method, the 'atomizer' test. The details of this procedure were described at the 1951 Convention of the American Electroplaters' Society. In essence it depends, like the water-break test, on the fact that the presence of oil on a metal surface decreases its wettability by water. It is, however, much more sensitive than water-break, for reasons which have been discussed in some detail in an earlier report.

In order to establish more fully the superiority of the atomizer method, comparative tests were made by all methods previously developed for commercial evaluation of efficacy of degreasing. The results of the comparison are summarized in the present report.

Influence of Organic Compounds on Crystal Growth of Electrodeposited Nickel

F. DENISE and H. LEIDHEISER: 'An X-ray Study of the Effect of Organic Compounds on the Crystal Growth of Nickel during Electrodeposition.'
Jnl. Electrochemical Soc., 1953, vol. 100, Nov., pp. 490–5.

A comprehensive study is being made, at the Virginia Institute for Scientific Research, of the interaction of organic compounds with a nickel surface during electrodeposition. This paper reports results of part of this investigation, covering X-ray diffraction analysis of deposits prepared from solutions containing, singly, 29 different organic compounds. The basis solution was of the Watts type, containing

$NiSO_4.6H_2O$	240 g./L.
$NiCl_2.6H_2O$	45 ,,
H_3BO_3	30 ,,

The solution was purified in the usual manner, by treatment with nickel carbonate, hydrogen peroxide, and activated carbon. In all cases the pH was adjusted with hydrochloric acid to 4·0. Details of conditions in individual experiments are given in the paper.

The compounds used were: *m*-aminophenol, *p*-aminosulphonic acid, aniline, benzaldehyde, benzaldehyde *m*-sulphonate (Ni salt), *m*-benzenedisulphonic acid (Ni salt), benzoic acid, benzonitrile, ethanolamine, ethanol, ethylamine, ethylenecyanohydrin, ethylenediamine, naphthalene-2, 7-disulphonate (Na), naphthalene-1, 3, 6-trisulphonate (Na), 1-naphthylamine-4, 8-disulphonic acid, nitrobenzene, phenol, *p*-phenolsulphonic acid, piperidine, propionitrile, pyridine, quinaldine ethiodide, quinoline ethiodide, saccharin, succinonitrile, thianaphthene dioxide, thiourea, *p*-toluenesulphonamide.

The respective organic compounds were evaluated with regard to their effects on the appearance, ductility, grain size and preferred orientation of the deposits. It was observed that they varied in their ability to

alter the grain size and the degree and/or type of preferred orientation. Compounds most effective in increasing the cathode potential during deposition both decreased the grain size and changed the type of orientation to a type other than (100) or to a random distribution of the crystals. Compounds which were less effective in increasing the cathode potential reduced the grain size, but had no effect on preferred orientation. Brittle deposits were characterized by an orientation other than (100); ductile deposits showed a (100) preferred orientation.

The results of this study, and the work of other authors to which attention is directed, indicate that a major fraction of mirror-bright electrodeposits of nickel exhibit no preferred orientation, but its absence does not necessarily result in brightness in the plating.

Comparative Corrosion-Resistance of Electroplated Coatings of Various Types

J. CHADWICK: 'Finishes Alternative to Conventional Nickel-Chromium.' *Electroplating*, 1953, vol. 6, Dec., pp. 451-5.

The author summarizes results of tests made (during the period of restricted nickel supply) on plated components exposed to test in marine, industrial and indoor atmospheres. In most cases the basis material was 70-30 brass strip: a few tests were also made on chromium coatings deposited on zinc-base die castings, steel, and copper. A high-temperature chromium-plating technique was found to give deposits showing corrosion-resistance much superior to those of conventionally produced chromium coatings.

Among the types of coating studied were (*a*) direct chromium on brass, steel and zinc-base alloys, (*b*) chromium coatings deposited on brass over underlays of copper, tin, tin-zinc, bright zinc, Speculum (copper-tin alloy), tin-zinc-copper, white brass (80-20 zinc-copper alloy), tin-nickel, cobalt, copper+silver, yellow bronze; (*c*) coatings of tin-zinc-copper alloy, tin produced by immersion coating, tin-nickel. Comparative tests, under identical conditions, were made on standard nickel+chromium coatings (0·0006 in. bright cobalt-nickel+0·00002 in. chromium).

From the behaviour of the various specimens, under the specific conditions employed in the tests, the author concludes that:—

The following coatings gave corrosion-resistance *equal to* that of standard nickel+chromium coatings: tin-nickel, chromium on copper+silver, chromium deposited by the high-temperature technique over Speculum.

The following coatings showed corrosion-resistance *superior to* that of the standard nickel+chromium finish: high-temperature chromium on underlays of tin-nickel, copper+silver, or yellow bronze.

Nickel-Phosphorus Corrosion-Resisting Coating

'Corrosion-Resisting Coating.' *Metal Progress*, 1953, vol. 64, Nov., pp. 103-4.

A coating claimed to afford unusually high corrosion-resistance on steel is produced by application (in paint form) of a mixture of nickel oxide and various phosphorus compounds, followed by heating to reduce the constituents of the coating to metallic nickel and phosphorus. The following notes are given on the process, which is covered by *U.S. Patent* 2,633,631: 'In the reduction by heat, advantage is taken of the fact that ammonium acid phosphate salts decompose in a reducing atmosphere at elevated temperatures, to form phosphine, water vapour, free ammonia, hydrogen and nitrogen. Reducing gases, along with liberated hydrogen, produce a metallized form of nickel from the oxides. Simultaneously, phosphine reacts with nickel oxide and nickel, to form metallic nickel phosphide. Since rather small amounts of phosphorus alloyed with nickel greatly reduce the melting point of the combinations, there results a wettable and flowable coating at the temperature of the operation. The usual reducing temperature range is 1550°-1700°F. (842°-926°C.). This is in the range of the usual normalizing temperatures for steels, and therefore will not cause excessive grain growth.

'Where vessels are too large to be heated by a regular furnace operation, an alternative method comprises spraying of the nickel-phosphorus alloy directly on the surface to be treated. Advantage is then taken of the flowability and wetting properties of the alloy combination, to produce bonding to the base metal. In such cases induction heating or other suitable localized reduction heating methods can be used.'

Design of Car Parts for Nickel Plating

D. M. BIGGE: 'Boosting Luster Life of Nickel-Coated Car Parts.' *S.A.E. Jnl.*, 1953, vol. 61, Sept., pp. 61-3.

Based on paper entitled 'Chromium-Plated Automobile Parts . . . Their Materials, Designs, and Finishes', presented at S.A.E. National Passenger-Car, Body, and Materials Meeting, March, 1953.

The basis of the argument is that, in order to obtain maximum service, car parts which are nickel- or nickel+chromium -plated should be simple in design, since distribution of nickel is more uniform on shapes which are free from sharp angles. Some illustrations are given to demonstrate forms and angles which (*a*) favour, or (*b*) prevent, satisfactory electrodeposition of nickel coatings. The author also points out that scratches in the base metal can more easily be removed, prior to plating, from smooth-contoured parts.

The full paper can be obtained from the S.A.E. Special Publications Department, 10, McGovern Avenue, Lancaster, Pa.. U.S.A., price 25 c. per copy.

Measurement of Thickness of Coatings by Anodic Dissolution

C. F. WAITE: 'Thickness of Electrodeposited Coatings by the Anodic Solution Method.' *Plating*, 1953, vol. 40, Nov., pp. 1245-8.

Following observations on the uncertainty of results obtainable by the hydrochloric-acid drop test for measurement of thickness of chromium deposits on copper, the author has developed an anodic-solution procedure modified from that proposed by H. F. FRANCIS (see *Trans. Electrochem. Soc.*, 1948, vol. 93, pp. 79-83). The principle of the instrument is the

anodic dissolution of a defined area of the plated metal, using the current-time product as a measure of the thickness. The modified method, of which full details are given, is being successfully used to measure the thickness of nickel and chromium on copper and of chromium on nickel. It may also be employed for estimation of thickness of cadmium, zinc, and copper coatings on steel.

Electroforming of Prototype Parts

'Electroformed Prototypes.' *Machinery* (*Lond.*), 1953, vol. 83, Nov. 20, p. 1006.

Short note describing manufacture of a movement case produced (for a motor-accessories firm) by electroforming in nickel and copper, on a Perspex master. The method used was that described (*ibid.*, Jan. 16, 1953) as being operated by London and Scandinavian Metallurgical Company, Ltd. The same technique has been adopted for production of radar wave guides required to have extremely accurate internal dimensions.

Corrigendum

Nickel Bulletin, 1953, vol. 26, Nos. 8-9, p. 137. 'Electroless Plating: the Kanigen Process' for *Production Engineering*, read *Product Engineering*.

NON-FERROUS ALLOYS

Control of Quality in Wrought Non-Ferrous Metals and Alloys: Monograph

Inst. Metals: 'The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys. I. The Control of Quality in Melting and Casting.' *Inst. Metals Monograph and Report Series No. 15*, 1953; 88 pp.

This volume contains the papers and discussion presented at the Symposium held in London during the Annual General Meeting of the Institute of Metals in March, 1953. The scope of the individual contributions is indicated below:

A. R. E. SINGER: 'The Principles of Technical Control in Metallurgical Manufacture.' pp. 5-16.

The effects of economic and technical factors, on the quality of manufactured products, are examined, and the characteristics of controlled processes are analyzed in terms of basic principles. Some aspects of statistical control of plant are considered in relation to present practice and probable future developments.

M. COOK and C. L. M. COWLEY: 'The Control of Quality in the Production of Brass Ingots and Billets.' pp. 17-26.

The paper is mainly concerned with the application of basic principles and practical knowledge, for the purpose of eliminating or minimizing the incidence of defects, and thus ensuring consistent production of high-quality brass castings for manufacture of alloys in wrought form. Control of raw materials, as well as melting and casting methods, is considered.

J. SYKES: 'The Control of Quality in Melting and Casting Copper and High-Conductivity Copper-base Alloys.' pp. 27-39.

Selection of raw materials and make-up of charges are discussed in relation to the type of furnace used. The fire-refining process for production of high-conductivity copper is described and control methods are dealt with in some detail.

Qualities desirable in mould dressings are considered, and pouring temperatures and speeds are discussed, as affecting the final castings. Methods used in production of alloy coppers are included in the review. Casting defects and their causes are listed, and some details are given of testing, analysis, and inspection methods employed for this type of product.

C. W. ROBERTS and B. WALTERS: 'The Control of Quality in the Casting of Zinc and Zinc-Alloy Rolling Slabs and Extrusion Billets.' pp. 40-50.

The metallurgical principles involved in production of zinc-base slabs and billets are examined; the origins of the defects normally encountered in the castings are indicated and means adopted for prevention of such defects are discussed. The importance of chemical control of the composition of both the raw materials and the finished castings is emphasized.

R. T. STAPLES and H. J. HURST: 'The Control of Quality in the Melting and Casting of Aluminium Alloys for Working.' pp. 51-65.

Problems arising in melting and casting of aluminium alloys and methods of securing optimum quality are discussed in relation to nine standard groups of alloys intended for use in wrought form. Effects of alloying additions, influence of impurities and incidental contaminants, melting and casting methods, and inspection methods are considered.

R. G. WILKINSON and S. B. HIRST: 'The Control of Quality in Melting and Casting Magnesium Alloys for Hot Working.' pp. 66-74.

Present practice in production and quality control are considered, with particular reference to three principal types of magnesium alloy used for wrought purposes: magnesium-manganese, -aluminium-zinc-manganese, and -zirconium-zinc.

Nickel-Uranium Alloys: Constitution and Structure

J. D. GROGAN and R. J. PLEASANCE: 'A Survey of the Uranium-Nickel System.'

B. E. WILLIAMS: 'An X-Ray Examination of Some Uranium-Nickel Alloys.' (Appendix to above paper.) *Jnl. Inst. Metals*, 1953-54, vol. 82, Nov., pp. 141-7; Advance Copy 1506.

Report of examination of the whole system, by thermal analysis, heat-treatment, and microscopical examination, supplemented by X-ray analysis of selected alloys.

The authors present an equilibrium diagram, and make the following summary of their conclusions:—

'The liquidus of the system uranium-nickel takes the form of two eutectic troughs; one is composed of U_6Ni and a compound approximately U_7Ni_9, melting at 740°C. and containing about 10·5 wt.-% (33 at.-%) nickel, the other of UNi_5 and nickel, melting at 1110°C. and containing about 71 wt.-% (91 at.-%) nickel. These are separated by a peak which rises to 1305°C., the melting point of UNi_5. The following compounds are formed by peritectic reactions: U_6Ni at 790°C.; compounds approximately of compositions U_7Ni_9 and U_5Ni_7 at 785° and 820°C., respectively; UNi_2 at 985°C. and a compound containing 78–79 at.-% nickel at 1290°C. Another compound occurs, containing approximately 77 at.-% nickel. The exact ranges of composition and the formulæ of the compounds have not been determined; the formulæ suggested are adopted for the sake of convenience. The existence of compounds U_6Ni, UNi_2 and UNi_5 has been established elsewhere by X-ray methods. The solid solubility of nickel in uranium is nearly 0·5 wt.-% (2 at.-%) at 790°C. and decreases with temperature. The solid solubility of uranium in nickel is about 0·75 wt.-% (0·18 at.-%) at 1000°C. and decreases with temperature.'

Nickel-Gold Alloys: Internal Friction

C. ANG and C. WERT: 'Internal Friction of Alloys of Gold and Nickel.' *Bull. Amer. Physical Soc.*, 1953, vol. 28, Nov., p. 18.

Abstract of paper to American Physical Society. The internal-friction behaviour of gold-nickel alloys was observed within the range 20°–700°C. In all the alloys examined two peaks were observed: one a grain-boundary peak at about 400°C., the other the 'pair-relaxation' peak referred to earlier by Zener, as occurring at lower temperatures. The presence or absence of this second peak depends on prior heat-treatment: it disappears on isothermal annealing at about 300°C., due to the occurrence of phase separation in the quenched alloy.

Chemical Polishing: Review of Recent Developments

See abstract on p. 2.

Induction Welding of Nickel-Alloy Tubing

'High-Speed Welding of Non-Ferrous Tubing.' *Welding Jnl.*, 1953, vol. 32, Nov., pp. 1098–9.

This short article records the development, by the Yoder Company (U.S.A.), of a process for production of tubing from coiled non-ferrous strip, by induction welding, carried out at speeds ranging from 40 to 120 f.p.m., depending on the type of material being handled, and the gauge and diameter of the tubing. Tests on the tubes show consistently high strength in the weld, and uniformly narrow weld zones, with a grain structure almost unaffected by the heating involved. It is claimed that the method can be successfully applied to almost the entire range of aluminium alloys available in coiled-sheet form; to certain magnesium alloys; to a wide range of copper-base alloys; to nickel and high-nickel alloys such as Monel and Inconel; to austenitic and ferritic stainless steels, and to light gauges of carbon steels. Typical Yoder tube mills are illustrated.

Nickel-Phosphorus Corrosion-Resisting Coating

See abstract on p. 4.

NICKEL-IRON ALLOYS

Magnetic Nickel Alloys in Telecommunications

C. E. RICHARDS and A. C. LYNCH (Editors): 'Soft Magnetic Materials for Telecommunications. *Published by Pergamon Press, Ltd., London*, 1953; 346 pp.

This volume contains (in slightly shortened form) the papers and discussions presented during the Symposium held at the Post Office Engineering Research Station, Dollis Hill, in April, 1952. It is pointed out, in a foreword by L. F. BATES, that the material thus made available comprises 'a very up-to-date account of the many important facets of magnetic experiment and theory. Theories concerning high initial permeability and low coercivity, hysteresis losses, magnetic viscosity, the properties of ferromagnetic powders, and the production and properties of ferrites, are discussed, and the book is likely to be, for some time to come, an authoritative guide in this field of knowledge.' The individual contributions are listed below:—

M. KERSTEN: 'Theoretical Remarks on the Influence of Slight Heterogeneous Impurities on the Initial Permeability of Nickel-Iron Alloys', pp. 1–8; disc., p. 8.

G. BATE, D. SCHOFIELD and W. SUCKSMITH: 'Coercivities in Dilute Ferromagnetic Alloys', pp. 9–13; disc., pp. 13–14.

L. NEEL: 'The Influence of Subdivision into Elementary Domains on the High-Frequency Permeability of Ferromagnetic Conducting Bodies', pp. 15–18.

G. C. RICHER: 'The Cardinal Magnitudes of Technical Magnetization', pp. 19–26.

J. GREIG and H. V. SHURMER: 'Iron Losses under Superimposed Alternating Inductions', pp. 27–36; disc., pp. 36–7.

K. E. LATIMER: 'Non-Linearity in Magnetic Core Materials at Low Field Strengths', pp. 38–48; disc., pp. 48–50.

H. P. J. WIJN: 'Frequency-Dependence of Magnetization Processes in Ferrites and its Relation to the Distortion caused by Ferrite Cores', pp. 51–62; disc., pp. 62–3.

V. G. WELSBY: 'Hysteresis Intermodulation in Directional Filters', pp. 64–73.

D. POLDER: 'Physical Aspects of Losses in Soft Magnetic Materials', pp. 74–82; disc., pp. 82–9.

F. F. ROBERTS: 'Ferromagnetic Resonances, Hysteresis and Residual Losses in Ferrites and Metals', pp. 90–5; disc., pp. 95, 82–9.

T. A. DUNTON: 'Relaxation Phenomena in Carbonyl Iron', pp. 96–106; disc , pp. 106, 86.

R. FELDTKELLER: 'Richter-type After-Effect of the Permeability in Silicon-Iron Laminations', pp. 107–18; disc., pp. 119, 86.

R. FELDTKELLER: 'Jordan-type After-Effect (Residual Loss) in Powder Cores', pp. 120–8; disc., pp. 129, 86.

J. C. BARBIER: 'The Thermal-Agitation After-Effect', pp. 130–4; disc., p. 86.

I. EPELBOIN: 'A Study, with the Aid of Electropolishing, of the Behaviour of Soft Magnetic Materials (Nickel-Iron Alloys) over a Wide Frequency Range', pp. 135–44; disc., p. 188.

A. FAIRWEATHER: 'On the Theory of Residual and Stratification Losses', pp. 145–52.

L. F. BATES, A. V. DAVIES and D. J. HARPER: 'A Calorimetric Method of Finding the Total Loss in Ferromagnetic Specimens Subjected to an Alternating Magnetic Field', pp. 153–9; disc., pp. 159–60.

F. F. ROBERTS: 'A Screening-Factor Technique for Permeability Determination and Some Experimental Results', pp. 161–71; disc., p. 171.

R. STREET and F. C. WOOLLEY: 'Irreversible Magnetic-Viscosity Effects', pp. 172–82.

A. C. LYNCH: 'The Assessment of Inhomogeneity in Thin Strips of High-Permeability Alloys', pp. 183–7; disc., pp. 187–90.

G. R. JACKSON, W. S. MELVILLE and D. W. R. SEWELL: 'Some Problems of Oscillographic Measurement of Characteristics of 'Rectangular'-Loop Magnetic Materials', pp. 191–6.

N. C. TOMBS: 'X-Ray Diffraction Methods in the Appraisal of Nickel-Iron Powder-Cores', pp. 197–201; disc., p. 201.

A. TAYLOR: 'The Structure of Carbonyl Iron', pp. 202–17; disc., pp. 217, 243.

F. ASSMUS: 'Experimental Investigations on Nickel-Molybdenum-Iron Alloys with Extremely High Initial Permeability', pp. 218–24.

W. F. RANDALL and H. H. SCHOLEFIELD: 'The Properties and Potentialities of Cold-Reduced Nickel-Iron', pp. 225–32.

C. E. RICHARDS: 'Some Chemical and Physical Properties of Iron Powders and their Effects on the Magnetic Properties', pp. 233–42; disc., pp. 242–6.

C. E. RICHARDS and D. C. SHOTTON: '50/50 Carbonyl Nickel-Iron Powders', pp. 247–52.

P. R. BARDELL: 'Factors Influencing the Measured Value of Hysteresis Loss of Powder-Cores', pp. 253–7; disc., pp. 257–8.

J. MCFARLANE and N. F. MOLE: 'Some Properties and Applications of Silicon-Iron', pp. 259–67.

G. CAMPBELL and F. J. WOODS: 'A Laminated Flake-Iron Powder Material for Use at Audio and Ultrasonic Frequencies', pp. 268–77.

A. L. MORRIS: 'The Pulse Characteristics of Ferrite Magnetic Materials', pp. 278–85; disc., p. 285.

P. F. DOREY: 'Some Pulse Tests on Magnetic Specimens having Rectangular Hysteresis Loops', pp. 286–99; disc., pp. 299–300.

A. E. DE BARR and E. H. FROST-SMITH: 'Magnetic Cores for Instrument Transductors', pp. 301–12.

S. E. BUCKLEY, G. A. JACKSON and A. G. F. THOMAS: 'Some A.C. Measurements on a Material having a Rectangular Hysteresis Loop', pp. 313–19; disc., pp. 319–21.

P. POPPER: 'The Magnetostriction of Ferrites', pp. 322–32.

Nickel-Iron Alloys in Polarized Relays

J. S. GARVIN: 'A New General-Purpose Polarized Relay.' *Bell Laboratories Record*, 1953, vol. 31, Oct., pp. 392–6.

Most of the relays used in the Bell System are of the 'neutral' type, i.e., they will move the armature in one direction only, regardless of the direction of current flowing through the winding. There is, however, a small group of relays which is fundamentally different from the neutral type, in that the direction of movement of the armature depends upon the direction of the operating current. Such relays, which are known as the 'polarized' type, perform many important functions, e.g., notification of the answer of a caller in machine switching systems, and also control of many other switching operations. Polarized relays are characterized by swiftness of working, and are extremely sensitive, some being adjusted to operate on as little as 0·2 milliwatt.

This article describes typical polarized relays, indicating the precision of design, mode of installation and working, and drawing attention to the contribution which has been made, to this development, by the advent of improved high-permeability nickel-iron alloys of the Molybdenum-Permalloy and related types.

CAST IRON

Ni-Hard Equipment in Crushing Mills

B. G. MACDERMID: 'Rod Milling at Snow Lake.' *Canad. Mining and Metallurgical Bull.*, 1953, No. 497, pp. 535–46, Sept.; *Trans. Canad. Inst. Mining and Metallurgical Engineers*, 1953, vol. 56, pp. 271–82.

The 2,000-ton capacity flotation-cyanidation mill of Howe Sound Exploration Company, Ltd., Snow Lake (Manitoba) Division went into service in March, 1949. The design of the crushing plant provided for primary crushing, in a 36-in. × 48-in. jaw crusher located underground, and secondary crushing in two 5½-ft. Standard Symons cone crushers on the surface, operated in open circuit. The intermediate range of comminution, between crushing and fine grinding, was to be performed by two 8-ft. × 12-ft. rod mills. Proportion of oversize in the product from the Symons crusher was high and the extremely abrasive nature of the coarse fractions resulted in rapid wear of mill liners and grinding rods, making control of abrasion the most important problem in operation of the rod mills. This paper describes designs and methods of working which, during the first 3½ years of working, were tried as a means of solving the difficulty. Particular attention is given to procedures developed for control of rod slippage, thus reducing rate of wear of the shell liners. The information given includes some comparisons of the behaviour of manganese steel and of Ni-Hard cast iron in the liners.

Structure of Graphite Spheroids

A. WITTMOSER: 'The 'Nuclei' of Spheroidal Graphite.' *International Foundry Congress*, 1953, Sept., Paper CI-25;

See also *Giesserei, Tech. Wiss. Beihefte*, 1953, vol. 12, Oct., pp. 571–85.

The structure of graphite spheroids is discussed in detail, and experimental evidence, directed towards explaining the apparent nucleus at the centre of certain spheroids, is presented. An extensive *bibliography* supports the review of publications relating to the form and nature of spheroids.

Colour Metallography of S.G. Iron

A. SCORTECCI and C. DURAND: 'The Use of Colour Metallography in Studying Spheroidal-Graphite Cast Iron.' *International Foundry Congress*, 1953, Sept., Paper MO-4; 11 pp.

The authors report a detailed investigation of the effects of heat-tinting flake-graphite and spheroidal-graphite cast irons, in the as-cast and the annealed conditions. The paper is well illustrated by coloured

photomicrographs. The S.G. irons examined included specimens of irons of low and of high silicon content, ingot-mould iron, spun pipe, and austenitic iron. A sample of blackheart malleable iron was also examined.

Production of Pressure-Tight Valve Castings in S.G. Iron

E. MORTARA: 'Practical Study of Gating and Feeding for Production of a Pressure-Tight S.G. Iron Casting.' *International Foundry Congress*, 1953, Sept., Paper CI-29; 15 pp.

The author opens with a discussion of the behaviour, during solidification, of eutectic and hyper-eutectic S.G. irons, produced from the cupola or from the electric furnace. Practical recommendations are then made on pouring, gating and feeding methods. The major part of the discussion deals specifically with procedure developed for production of pressure-reducer valves for gas mains. These castings are tested at 100 atmospheres and are required to be completely tight. It is pointed out that, by comparison with steel, S.G. iron offers particular advantages for pressure valves, in that there is less risk of foundry defects liable to cause lack of pressure-tightness; S.G. iron has improved machinability and there is also less excess material to be machined; a reduction in section thickness is in many cases made possible by the better fluidity and castability of S.G. iron, and its use obviates the necessity for welded-on parts which must otherwise be employed.

Italian State Railways Specification for S.G. Iron

'Italian State Railways Approve Use of S.G. Iron Specifications for Acceptance.' *Il Nickel*, 1953, June, pp. 19-20.

The Italian State Railways have recently approved the use of S.G. iron for various items, and have issued tentative specifications to govern acceptance of castings of two grades: GS 55, as-cast or annealed, and GS 40, annealed. It is required that the microstructure shall show a minimum of 90-95 per cent. of graphite in nodular form. The mechanical properties called for are shown in the following table:—

	Tensile Strength		Yield Point		Elongation % min.	B.H. No.
	t.s.i. min.	kg./mm² min.	t.s.i. min.	kg./mm² min.		
GS55	34·9	55	25·4	40	3	200–250
GS40	25·4	40	19	30	10	200

Influence of Welding on Structure of S.G. Iron

E. E. HUCKE and H. UDIN: 'Welding Metallurgy of Nodular Cast Iron.' *Welding Jnl.*, 1953, vol. 32, Aug., pp. 378S-85S.

The authors present a detailed analysis of the structural changes which occur in ferritic S.G. iron when subjected to the rapid heating and cooling cycles associated with brazing and with metallic-arc and oxy-acetylene welding processes. The essential features of the microstructure of the heat-affected zone are illustrated in a series of photomicrographs.

Impact Properties of S.G. Iron

A. L. CARR and W. STEVEN: 'The Impact Properties of Annealed Spheroidal-Graphite Cast Iron.' *International Foundry Congress*, 1953, Sept., Paper MO-3; 20 pp., see also *Metal Treatment*, 1953, vol. 20, Oct., pp. 455-61.

The authors demonstrate that annealed S.G. iron has an impact-transition temperature range similar to that observed for steel. At temperatures above the transition range the iron breaks with a dark, tough fracture, and has a relatively high impact value, whilst below that range the fracture is bright and crystalline, and the impact value is low. The impact strength of notched bars falls steadily as the percentage of crystalline fracture increases, whereas that of notched bars does not begin to diminish until the fractures are almost completely crystalline. The basis composition of the irons studied was: carbon 3·0–3·5, silicon 2·0–2·5, manganese 0·15, phosphorus 0·02, nickel 1, per cent. Sufficient magnesium was added to give fully spheroidal graphite structures. The investigation covered a determination of the separate effects, on impact properties, of variations in silicon, manganese, and phosphorus contents, and of up to 35 per cent. residual pearlite. Increase in silicon content from 1·4 to 4·6 per cent. raised the transition range by more than 200°C.; when the silicon exceeded about 3 per cent. the range was mainly above room temperature and the iron had poor notched and un-notched impact properties at room temperature. The effect of raising manganese to 1·4 per cent., was similar, but milder in degree. Raising the phosphorus to 0·16 per cent. had only a slight influence on impact properties, although some phosphide eutectic was present in the microstructure, but further increase in phosphorus, to 0·30 and 0·57 per cent., caused formation of networks of eutectic and was accompanied by marked deterioration in impact properties.

One of the major effects of residual pearlite was to impair the uniformity of impact resistance. Less than about 10 per cent. had little effect, but larger amounts, up to 35 per cent., raised the transition ranges and lowered the impact values above that range.

Three criteria were used to assess transition temperature: the temperatures at which the fracture contained 10 or 90 per cent. fibrous (dark) area, and the temperature at which the impact value had fallen to half its average value at temperatures above the transition range. Except in high-phosphorus irons and in the irons containing residual pearlite, impact-transition

temperature was approximately proportional to Brinell hardness, and it is shown that approximate relationships between hardness and room-temperature impact values make possible calculation of the probable impact properties of a fully annealed iron. The authors' results and conclusions are compared with those of other investigators.

Thermal Conductivity of S.G. Iron

M. J. SINNOTT: 'Thermal Conductivity of Nodular Iron.' *Jnl. of Metals*, 1953, vol. 5, Aug.; *Trans. Amer. Inst. Mining and Metallurgical Engineers*, p. 1016; Tech. Note 171E.

The authors report tests on five S.G. irons, the compositions of which are shown in Table I below.

The compositions of irons I–IV were chosen to demonstrate the influence of silicon: test specimens were from laboratory melts cast into 4-in. keel blocks. Iron V was a commercial casting, in which the test piece was cut from the centre of a 3-in. × 10-in. × 26-in. billet. All tests were made on the irons in the as-cast condition.

The results (temperature range 210°–160°F.: 99°–71°C.) are given in Table II below.

It will be seen that rise of silicon is accompanied by lowering of thermal conductivity, although the structure is changing from pearlitic to ferritic, a change which is usually associated with increased conductivity. The thermal conductivity of the nodular irons studied was less than that of regular foundry irons by some 10–30 per cent. and also less than that of malleable iron. The cause of the lower conductivity is believed to be the more highly alloyed ferrites obtained in the nodular irons, and the changed mode of distribution of the graphite, as compared with that observed in foundry irons.

CONSTRUCTIONAL STEELS

Engineering Steels: Textbook

L. AITCHISON and W. I. PUMPHREY: 'Engineering Steels. A Study of the Properties of Steels and the Principles Governing their Selection for Engineering Applications.' *Published by Macdonald and Evans, Ltd., London*, 1953; 923 pp. Price £5 5s. 0d.

The authors point out in their preface that developments in steel metallurgy during the past quarter of a century have been mainly in two directions; *first*, the evolution of steels having properties which will satisfy the demands of special branches of engineering, e.g., materials for high-temperature applications or for use in various branches of chemical engineering; *second*, the treatment of established steels by improved methods which will confer on them mechanical properties unattainable in earlier years. These developments have been associated with research and trials of a highly specialized type, and metallurgy has become, in all its branches, too complex a subject to be readily and fully studied by the user of steels, the engineer. If, however, he is to use the materials available to him to maximum advantage he must have a

Table I

Iron No.	Total C %	Si %	Mn %	S %	P %	Ni %	Mg %
I	3·57	1·12	0·33	0·004	0·035	1·33	0·06*
II	3·56	2·27	0·33	0·010	0·025	1·30*	0·06*
III	3·47	3·53	0·29	0·012	0·030	1·30*	0·06
IV	3·36	4·34	0·40	0·010	0·030	1·23	0·06
V	3·33	2·28	0·50	0·010	0·055	1·12	0·06

* Estimated

Table II

Iron No.	C.g.s. units	Pearlite %	Ferrite %	Graphite %	Graphite Size in. × 100
I	0·090	61	30	9	0·186
II	0·089	40	50	10	0·121
III	0·086	35	55	9	0·096
IV	0·084	5	85	10	0·081
V	0·085	85	5	10	0·175

clear understanding of some fundamental facts which influence the behaviour of his 'raw material'.

This book is written with the aim of making steel comprehensible to those who use it, and to that end the authors have marshalled, in a scientific and yet practical manner, information based on theory, principles, tests and experience. The scope of the book is comprehensive, covering production; thermal and and mechanical processing; hardenability; mechanical testing methods; compositions and properties of carbon and of low- and high-alloy steels; welding and brazing; machinability; scrap recovery; corrosion and protection. Each of the 18 chapters is supplemented by a selected *bibliography*, and a series of appendices contains further references to the literature, information on British Standard Specifications, conversion tables, terms and definitions relating to heat-treatment, design factors significant in relation to steel structures, and other miscellaneous data which may prove useful to the metallurgist and engineer. A feature of the book is the very large number of illustrations, and the wealth of data presented in tabular, ready-reference form.

Partition of Nickel and Other Elements between Carbide and Ferrite

D. A. SCOTT and G. S. FARNHAM: 'The Partition of Some Alloying Elements between Carbide and Ferrite in Steels.' *Jnl. of Metals*, 1953, vol. 5, Nov., Sect. II; *Trans. Amer. Inst. Mining and Metallurgical Engineers*, pp. 1541–3.

The objects of the investigation reported were: (1) to determine the partition of nickel between cementite and ferrite, in a medium- and high-carbon series of annealed nickel-alloy steels of various types; (2) to evaluate the effect of chromium and/or molybdenum on the partition of nickel in medium-carbon annealed steels; (3) to determine the partition of chromium between ferrite and carbide in a series of medium-carbon annealed steels, and (4) to study the nature of the carbides formed in a nickel steel (A.I.S.I. 2330) during (*a*) isothermal transformation, and (*b*) quench-and-temper treatments. The compositions of the steels used are shown in the Table below.

An electrolytic method used for separation of the carbides is described in some detail.

The experimental data recorded showed that, in 0·30–0·35 per cent. carbon steels, variously annealed, the alloying element in the carbide, expressed as a percentage of the total amount of alloying element, was approximately 2·7 per cent. for nickel, 18·3 per cent. for manganese, 35·0 per cent. for chromium, and 33·4 per cent. for molybdenum. Increasing nickel content did not affect the percentage values for the other elements, nor did the addition of chromium or molybdenum alone affect the percentage of nickel in the carbide. Combined additions of chromium and molybdenum, however, lowered the nickel content of the carbide.

With given nickel contents in the steel the percentage of nickel in the carbide was the same in steels containing 0·30–0·35 per cent. and 0·80–0·85 per cent. carbon. The percentage of total available nickel present in the carbide increased, however, from 2·8 to 8·1 per cent.

Increasing the holding time at 1150°F. (621°C.) of a 3·4 per cent. nickel steel containing 0·65 per cent. manganese resulted in a gradual replacement of nickel in the carbide by manganese from the ferrite. There is indication that the rate of replacement eventually slows down.

Production of Nickel-Chromium-Molybdenum Steel Hollow Propeller Blades

'Making Hollow Steel Propeller Blades.' *Machinery* (*Lond.*), 1953, vol. 83, Oct. 16, pp. 757–66; Nov. 13, pp. 939–47.

In *Machinery* of April 5, 1951 a description was given of processes employed by the Hamilton Standard Division, United Aircraft Corporation, U.S.A., in manufacture of hollow-bladed steel propellers, which offer considerable advantages in weight-economy and efficiency and in power-absorption in relation to diameter. Propellers of this type are produced in England by de Havilland Propellers, Ltd., in close co-operation with the Hamilton Company. The articles now published give a detailed and well illustrated account of practice in the de Havilland plant.

Analysis of Steels

Type	Range of Composition					
	C %	Si %	Mn %	Ni %	Cr %	Mo %
Med.–C, Ni ..	0·29–0·35	0·15–0·25	0·25–0·65	0·10–3·77	—	—
High–C, Ni ..	0·82–0·85	0·23–0·28	0·27–0·29	0·10–3·35	—	—
Cr ..	0·34–0·35	0·16–0·18	0·24–0·31	—	0·45–1·42	—
Ni–Cr ..	0·31–0·33	0·26–0·32	0·35–0·39	0·73–3·30	0·80–0·83	—
Ni–Mo ..	0·33–0·34	0·16–0·20	0·34–0·36	0·00–3·36	—	0·21–0·23
Ni–Cr–Mo ..	0·31–0·34	0·16–0·22	0·30–0·35	0·00–3·43	0·83–0·88	0·22–0·25

The blades currently made are approximately 96-in. long and have a maximum chord of 15·34 in. at the tips: they closely resemble the American counterparts, except that the sections towards the roots are larger. Each blade has an internal tubular core, flattened and twisted to the appropriate form, and having an integral root attachment. The core, which tapers in thickness from root to tip, is surrounded by a steel shell having the required profiles and twist, and serves as a spar and as a means of attaching the assembly to the hub. Vibration damping is obtained by the use of cellular rubber filling in the interior of the core and in the spaces between the shell and the core.

The material used for the cores is a nickel-chromium-molybdenum steel containing about 0·47 per cent. of carbon. The tensile strength of this steel, in the initially heat-treated condition, is 67 tons per sq. in., and in the course of subsequent processing this is raised to 80 tons per sq. in. An account is given (in the Oct. 16 issue) of the machining of the cores from the original forging, and the processes involved in forming. The second section (Nov. 13 issue) covers production and assembly of the outer shells, which are made from 20 s.w.g. nickel-chromium-molybdenum steel sheet containing 0·36 per cent. carbon. The tensile strength of the sheet is of the order of 40 tons per sq. in., which, during processing, is increased to about 60 tons. Stretch-forming, folding, and other operations are described, with illustrations, also the techniques employed in brazing the shell to the core, finishing of the shell, cavity filling, and final testing.

Ultra-High-Strength Nickel-Chromium-Molybdenum Steel for Aircraft

M. A. MELCON: 'Ultra-High-Strength Steel for Aircraft Structures.' *Product Engineering*, 1953, vol. 24, Oct., pp. 129–41.

During the past three years intensive research has been carried out by Lockheed Aircraft Corporation on the properties of nickel-chromium-molybdenum steel of the S.A.E. 4340 type (carbon 0·38–0·43, nickel 1·65–2·00, chromium 0·70–0·90, molybdenum 0·20–0·30 per cent.) heat-treated to strengths much higher than those conventionally used in steel for aircraft structures. The report of the work is contained in this paper, which shows the suitability of steel having a tensile strength of 260,000–280,000 p.s.i. (116–125 tons per sq. in.) for such purposes. The article includes records of tests made to establish static, impact, and fatigue characteristics of the steel in the ultra-high-tensile condition, also data on notch-sensitivity, and notes on processing techniques (machining, welding, and plating and finishing). As a result of the investigations reported, Lockheed have adopted certain processing practices which differ in some respects from those usually employed for similar steel heat-treated to lower strengths. The main aspects of such techniques are summarized.

Nickel-containing Materials in Small Gas Turbines

See abstract on p. 12.

Production of Nickel-Alloy Steel Connecting Rods for Diesel Engines

'Producing Connecting Rods for Diesel Engines.' *Machinery* (*Lond.*), 1953, vol. 83, Dec., pp. 1135–45.

The article gives a detailed and well-illustrated description of equipment and methods employed in the works of F. Perkins, Ltd., of Peterborough, in manufacture of connecting rods for their P series of Diesel engines. These components are made from a heat-treated nickel-chromium-molybdenum steel to B.S. specification En 24U (carbon 0·35–0·45, nickel 1·30–1·80, chromium 0·90–1·40, molybdenum 0·20–0·35, per cent., in the 60-ton tensile condition).

Nickel-Molybdenum Steel Magnet Chain

'Magnet Chains.' *Iron and Steel Engineer*, 1953, vol. 30, Oct., pp. 212, 214.

Heat-treated nickel-molybdenum steel has for many years been successfully used for sling chains, and experience with it has recently led to the adoption of the same material for a new type of lifting and transporting magnet chain introduced by a chainmaker in U.S.A. The new unit is designed to eliminate friction, twisting and gouging in service, which tend to cause excessive wear, and the form of the whole unit is such as to ensure level lifting and even weight distribution, thus making it impossible for chains to 'gang up' on the ring. The entire assembly (chain, ring, and other parts) is made from the nickel-molybdenum steel, treated to obtain maximum strength and toughness. The high tensile strength of this steel permits handling of very heavy loads with gear of relatively small size, e.g., a 1¾-in. diameter three-leg alloy steel chain on a 65-in. magnet will raise loads up to nearly 50 tons. A further advantage is that the alloy-steel chain requires no maintenance annealing during service, and remains highly resistant to shock at both normal and sub-zero temperatures, to work-hardening effects, and to fatigue stresses.

Welding of Nickel-Alloy Steels for Sub-Zero Service

R. W. BENNETT: 'Welding for Low-Temperature Service.' *Welding Jnl.*, 1953, vol. 32, Nov., pp. 1089–97.

This paper deals with the properties of the various weld metals and base materials used in the fabrication of pressure vessels and heat-exchangers for low-temperature service, and with some tests used for their evaluation. Transition-temperature curves of the Charpy notched-bar tests on various types of weld metal show that electrodes of the A.W.S. E-6020* and E-7020* types will meet A.S.M.E. Code requirements for welding killed carbon steels to be used at

* *E-6020 and E-7020 Electrodes.* (Horizontal fillet welds and flat position: direct or alternating current.) Essentially mineral-covered electrodes having a high percentage of iron oxide, manganese compound, and silica in the covering, together with sufficient alloys to give a deposit of the desired composition. The core wire is, in most cases, 0·10–0·14 per cent. carbon steel.

E-8016 Electrodes. (All-position: direct or alternating current, reversed polarity.) The coverings, consisting largely of minerals of which a high percentage is soda and lime carbonate, are classified as low-hydrogen/sodium type. The core wire is usually a rimmed steel of the carbon 0·10–0·14 per cent. type, with specified contents of manganese, sulphur and phosphorus. Such electrodes have been developed for welding high-strength, high-carbon alloy steels, in which the ordinary coverings produce underbead cracking.

temperatures down to −50°F. (−46°C.). For service at lower temperatures, e.g., down to −150°F. (−101°C.) certain brands of A.W.S. Class E-8016* electrodes are suitable for welding low-alloy steels such as 3½ per cent. nickel and chromium-copper-nickel grades. Correlation of the metallurgical structure of weld metal with Charpy notched toughness has shown that a welding technique producing fine-grained weld metal is essential to obtain optimum toughness.

Induction Welding of Nickel-Alloy Tubing

See abstract on p. 6.

Chemical Polishing: Review of Recent Developments

See abstract on p. 2.

HEAT- AND CORROSION-RESISTING MATERIALS

Pickling and Annealing of Nimonic Alloys

HENRY WIGGIN AND CO., LTD.: 'Notes on the Annealing and Pickling of Nimonic 75 and Nimonic F.' *Publn. 672*†, 1953; 4 pp.

This publication supersedes an earlier one on the same subject. It embodies information and recommendations based on later developments in technique and on further experience which has recently been accumulated. Conditions for annealing are specified, and particulars are given of procedure suitable for

(*a*) descaling by use of acid pickles;
(*b*) „ „ alkaline liquor, followed by acid dip;
(*c*) „ with fused alkali baths, followed by acid pickling.

Nickel-containing Materials in Small Gas Turbines

W. L. SLOSSON: 'Metallurgical Aspects of the Development of Small Gas Turbines.' *Jnl. of Metals*, 1953, vol. 5, Nov., pp. 1419–26.

During recent years the Boeing Airplane Company has been developing and manufacturing a series of small gas turbines for industrial and military use. In demonstration of the metallurgical problems involved in the design and production of such units, the author describes the construction and operating principles of the Boeing Model 502 turbine.

The engine has two stages, the first being the gas-producer, the second the power-output section. A diagram of the turbine is shown and materials used for the respective parts are listed, with the compositions of corrosion- and heat-resisting types. Requirements of materials for individual components are critically considered, in groups relating to the compressor section, the burner section, the first-stage nozzle assembly, and the first- and second-stage turbine wheel assemblies. Other aspects of the subject which are more briefly discussed are the welding of the turbine blades, the exhaust system, corrosion from fuel residues, problems introduced by cyclic operation, and the need for conservation of critical elements as influencing selection of materials for the Boeing 502.

Nickel-containing Materials in Marine Gas Turbines

'"R.M.60' Marine Gas Turbine.' *Engineer*, 1953, vol. 196, Nov. 13, pp. 617–621.

The article gives a detailed description of two medium-life experimental gas turbines, suitable for use as propulsion units for light, high-speed naval craft. The engines have been developed by Rolls-Royce, Ltd. Each has a compound cycle, and develops about 5400 b.h.p.: they are to be installed in the gunboat H.M.S. 'Grey Goose', for sea trials. Notes on materials employed for various components of the turbines include reference to the use of Nimonic alloys 90 and 80 for blading, of Nimonic 75 for the flame tube and swirl vane assembly, and of other high-nickel-containing materials for various parts.

Fatigue Properties of High-Temperature Alloy under Axial Loading

B. J. LAZAN and F. DE MONEY: 'Investigation of Axial Loading Fatigue Properties of Heat-Resistant Alloy N-155.' *Wright Air Development Center Tech. Rept.*, 52-226, Mar., 1953; 18 pp.

The report gives dynamic creep and stress-rupture data on low-carbon N-155 alloy,* at room temperature and at 1000°F. (538°C.). Temperature rise in the specimen observed under some conditions, immediately after application of alternating stress, is attributed to the high damping capacity of the alloy. It is pointed out that this effect introduces serious problems in testing techniques. An air-blast cooling method (incorporated in the furnace containing the test specimen) and a variable starting-up procedure, introduced to prevent the temperature rise, are described.

Sigma-Phase Embrittlement in 25-20 Chromium-Nickel Steels

(J. I. MORLEY and H. W. KIRKBY): 'Sigma-Phase Embrittlement in 25 Cr-20 Ni Heat-Resisting Steels.' *Jnl. Iron and Steel Inst.*, 1953, vol. 175, Dec., pp. 407–8.

Discussion on paper published *ibid.*, 1952, vol. 172, Oct., pp. 129–42; abstract in *Nickel Bulletin*, 1952, vol. 25, No. 11, p. 281.

E. J. DULIS presented data confirming the findings of the authors on the effect of prior treatment on sigma formation in this steel, and on the influence of sigma on its mechanical properties, both at room and at elevated temperatures. The discussion also included reference to variations in behaviour of individual steels in the group studied.

* *See footnote on p. 11.*
† *We shall be pleased to supply a free copy of this publication.*

* Complex nickel-chromium-cobalt-iron alloy.

Corrosion by Aqueous Solutions at Elevated Temperatures and Pressures

F. H. BECK and M. G. FONTANA: 'Corrosion by Aqueous Solutions at Elevated Temperatures and Pressures.' Reprint, issued by ALLOY CASTING INSTITUTE, of paper published in *Corrosion*, 1953, vol. 9, Aug., pp. 287–93; see abstract in *Nickel Bulletin*, 1953, vol. 26, Nos. 8–9, p. 149.

Engineering Steels: Textbook

See abstract on p. 9.

Composition and Properties of Cast High-Alloy Materials

E. A. SCHOEFFER: 'Cast High Alloys.' *Chemical Engineering*, 1953, vol. 60, Oct., pp. 298, 300, 302, 304, 306, 308–12.

A detailed practical discussion of the range of corrosion-resisting alloys of iron-chromium-nickel base standardized by the Alloy Casting Institute. Corrosion-resistance of the materials is demonstrated by data on their behaviour in contact with typical commercial corrosives, average mechanical and physical properties are tabulated and discussed, and the characteristics of the respective alloys are reviewed in relation to their suitability for various types of service. Some representative applications are illustrated.

Stress-Corrosion Cracking of Austenitic Chromium-Nickel Steels

(C. EDELANU:) 'Transgranular Stress-Corrosion in Chromium-Nickel Stainless Steels.' *Jnl. Iron and Steel Inst.*, 1953, vol. 174, July, p. 218, vol. 175, Dec., pp. 390–2.

Discussion on paper published *ibid.*, 1953, vol. 173, Feb., pp. 140–6; abstract in *Nickel Bulletin*, 1953, vol. 26, No. 4, pp. 66–7.

Points raised in discussion include: influence of grinding in initiating stress-corrosion; effect of purity of magnesium chloride used in testing; theory of the electrochemical nature of stress-corrosion; inhibition by nickel contents of 45 per cent. or above; association of 'quasi-martensite' and stress-corrosion; stresses required to cause martensitic transformation; use of U-bend test for investigation of stress-corrosion cracking.

Effect of Coupling of Aluminium and Stainless Steel on Resistance to Corrosion by Nitric Acid

M. G. FONTANA: 'Effects of Acid Velocity and Galvanic Couples on Corrosion of Aluminium and Stainless Steel in Strong Nitric Acid.' *Industrial and Engineering Chemistry*, 1953, vol. 45, Nov., pp. 91A–2A, 94A.

Preliminary record of work at Ohio State University laboratory. An illustrated description is given of pilot-plant equipment used for study of erosion-corrosion and velocity effects.

With few exceptions, erosion-corrosion usually causes increased attack, as compared with behaviour of identical materials in quiet solutions, although some exceptions are found, e.g., in solutions which cause pitting, or in conditions in which concentration-cell effects accelerate corrosion. Typical examples cited relate to decrease in corrosion of niobium-stabilized 18–8 chromium-nickel steel in white fuming nitric acid, with increased rate of flow, in comparison with more vigorous attack caused by increased velocity on aluminium exposed to the same corrosive.

Tests in which stainless steel and aluminium were coupled, in white fuming nitric acid, showed that at 108°F. (42°C.), with an acid velocity of 6·2 f.p.s., the corrosion loss of the stainless steel fell (from about 60 mil) to less than 1 mil per year, and that the rate of attack on the aluminium was not greatly increased, rising from 13 to 16 mil per year. The results indicate the possibility of protection of stainless steel by use of aluminium as a sacrificial anode, and it is noted that the protective effect on the steel increased with rise of temperature of the solution, although the corrosion of the aluminium increased.

Prevention of Pitting Corrosion during Pickling of Stainless Steels

N. SOLONY: 'Pitting Corrosion of Stainless Steels.' *Canadian Metals*, 1953, vol. 16, Sept., pp. 50–1.

It has been experimentally shown that during treatment of chromium-nickel stainless steels in mixed-acid solutions, for removal of oxide layers resulting from annealing, pitting corrosion occurs only when the acids are present in the range HNO_3 : HCl from 1 : 3 to 3 : 1. The work recorded in this note leads to recommendation of the following solution:—

50 g. HNO_3 (75 c.c. HNO_3, 34·5 Bé).
135 g. HCl (450 c.c. HCl, 17·0 Bé).

The solution should be used at a temperature not above 65°C., and the time of immersion varies, according to the nature of the steel surface and the condition of the bath, from 15 to 40 minutes. Undissolved fragments of oxide which break off from the metal during pickling tend to settle as a film on its surface. Before processing is continued the material should therefore be washed in water and lightly scrubbed with a brush or cloth, to remove the film or scale.

Occurrence and Prevention of Carbide Precipitation in Welding of Austenitic Steels

G. E. LINNERT and R. M. LARRIMORE: 'How to Control Carbide Precipitation in Welding Stainless Steels.' *Materials and Methods*, 1953, vol. 38, Nov., pp. 98–103.

The article constitutes an attempt to explain, in an easily comprehensible manner, the nature of carbide precipitation, the factors causing it, and methods of prevention. The following factors are discussed, as affecting precipitation of carbide: (1) *thickness of base metal* (thin gauges are more sensitive than thicker ones, since heat input is relatively heavy; (2) *the welding process* used (an arc applied directly to the work accomplishes the welding with less input of heat than the atomic-hydrogen or oxyacetylene methods); (3) *rate of welding* (fast rate of travel decreases sensitization); (4) *heat input* (lowest possible heat input,

secured by fast travel, reduces risk of carbide precipitation); (5) *cooling rate* (sensitization is minimized by rapid removal of heat from the base-metal zone).

Of the various methods which have been proposed for avoiding sensitization, three only are considered to be reliable: (1) *post-welding solution-annealing*; (2) *stabilization with strong carbide-forming elements* such as niobium, tantalum, or titanium; (3) *use of steels of extra-low carbon content*. The relative advantages and limitations of the three methods are critically discussed.

Induction Welding of Stainless-Steel Tubing

See abstract on p. 6.

Production of Stainless-Steel Needle Tubing

'Needle-Tube Production.' *Steel*, 1953, vol. 133, Nov. 2, pp. 90–1.

Step-by-step illustrated description of practice at the works of Superior Tube Company, Norristown, Pa., where millions of feet of tubing per month are drawn, in materials of over 50 compositions, including stainless steels and nickel-base alloys. The sizes produced range from 0·008 to 0·625 in. o.d., and certain varieties are made in sizes up to 2·0625 in. o.d., with very light walls. Tubing for hypodermic needles undergoes special treatment, to ensure the combination of tensile strength and flexibility which is essential in this application.

Brazing of Stainless Steels

'Stainless Steels. New Technique for Brazing in a Controlled Atmosphere.' *Iron and Steel*, 1953, vol. 26, Dec., p. 556.

The note calls attention to the development, by the General Electric Company, Ltd., of a procedure by which it is possible to braze stainless steels in a standard furnace provided with controlled atmosphere. The process is claimed to be suitable for both copper-brazing stainless steels and for brazing components in cases where Nicrobraz is used as the filler material. Brief details are given of the salient features of the new method.

Chemical Polishing: Review of Recent Developments

See abstract on p. 2.

Nickel-Phosphorus Corrosion-Resisting Coating

See abstract on p. 4.

PATENTS

Extraction of Nickel from Nickel-Copper Matte

Nickel-copper mattes containing insufficient sulphur to bind all the nickel and copper are comminuted, preferably after heat-treatment, and a metallic fraction consisting predominantly of nickel and copper is mechanically separated from the fraction containing nickel sulphide and copper sulphide. Nickel is subsequently recovered by treatment of the metallic fraction with nickel-dissolving agents, such as acids or salt solutions.

BADISCHE ANILIN- UND SODA-FABRIK. *Brit. Pat.* 698,162.

Recovery of Nickel and Cobalt from Copper-containing Solutions

Copper-contaminated liquor obtained by ammonia leaching of concentrates containing nickel, cobalt and copper is treated by the following method, to separate the nickel and cobalt in pure forms:—

The pH of the liquor is adjusted to 7–8, e.g., by boiling off excess ammonia. Sulphuric acid is then added, to bring the pH down to $\geq 6{\cdot}2$, in order to precipitate most of the nickel as nickel-ammonium sulphate. Further sulphuric acid is then added, to reduce the pH to ≥ 4, in order to secure precipitation of the rest of the nickel and most of the cobalt, as nickel- and cobalt-ammonium sulphate, respectively. The temperature is kept at about 135°F. (57°C.) during the sulphuric-acid treatment.

F. A. FORWARD, assignor to SHERRITT GORDON MINES LTD. *U.S. Pat.* 2,647,820. (This specification is to be read in conjunction with *U.S. Pat.* 2,576,314.)

Preparation of Nickel-containing Catalysts

In a process of catalytic hydrogenation the catalyst is a precipitate produced by the interaction, in solution, of an alkali metal borohydride with at least one soluble salt of nickel, cobalt, or copper, or a mixture of such salts.

A related patent specifies a catalyst comprising an intimate mixture of at least one 'boride' of nickel or cobalt (made by reaction of a solution of alkali metal borohydride with nickel or cobalt salts), with iron, chromium, molybdenum or tungsten as promoter metal.

A further patent specifies hydrogenation of streptomycin salts to dihydrostreptomycin, in the presence of nickel- or cobalt-boride catalyst of the type described in *British Patent* 700,396, and containing, optionally, a promoter as specified in 700,397.

STÉ. DES USINES CHIMIQUES RHÔNE-POULENC. *Brit. Pats.* 700,396, 700,397 and 700,398.

A mixture of a metal carbonyl and a halogen or halogen compound (preferably nickel carbonyl and iodine) is used as catalyst in the high-pressure, high-temperature carbonylation of saturated alcohols to aliphatic carboxylic acids and their esters.

BADISCHE ANILIN- UND SODA-FABRIK (inventors, W. REPPE and N. V. KUTEPOW. *Brit. Pat.* 699,556.

Prevention of Self-Discharge in Nickel-Alkaline Batteries

Self-discharge of Edison-type accumulators is prevented by the provision of an auxiliary zinc electrode, electrically connected to the iron negative electrode.

H. W .G. HIGNETT and P. HERSCH, assignors to INTERNATIONAL NICKEL CO., INC. *U.S. Pat.* 2,653,180.

Alloyed Nickel Cores for Coated Cathodes

The use of nickel containing zinc 0·1–0·5, aluminium 0–0·15, titanium 0–0·25, per cent. for cores of coated cathodes of thermionic valves is claimed to result in rapid development of emission and freedom from high-resistance interfaces between the core and the coating material. The alloys may be made by powder-metallurgy methods.

M. O. VALVE CO., LTD., and D. A. WRIGHT. *Brit. Pat.* 700,606.

Production of Fine Powders viâ the Carbonyls

Metal powders of small particle size and uniform size distribution are made by thermally decomposing a metal carbonyl in the free space of a reaction vessel, while irradiating the carbonyl with radiant energy or corpuscular radiation. The process is applicable to the production of powders of nickel, cobalt, iron and other metals.

GENERAL ANILINE AND FILM CORPN. *Brit. Pat.* 695,152 (corresponding to *U.S. Pat.* 2,604,442).

Carbonyl powders (of nickel, iron and other metals) having very small particle size and uniform size distribution are also made by thermal decomposition of a carbonyl in the free space of a reaction vessel, while the carbonyl is subjected to waves from a sonic generator. The reacting vessel is preferably heated to 470°–490°F. (248°–254°C.) and the sound waves should cause local temperature rises of 10°–20°F. (6°–12°C.).

GENERAL ANILINE AND FILM CORPN. *Brit. Pat.* 695,925.

Bright Nickel Plating

An acid aqueous nickel-plating bath contains nickel salts, an acid buffering agent, and an at least partially water-soluble organic compound containing an isothioureido nucleus and having an organic radical attached to the sulphur atom of the nucleus. The organic compound is dissolved in the bath in sufficient quantity to produce bright plating; the preferred addition is 0·01–1 per cent. of beta-isothioureido propionic acid.

H. G. DONNELLY, assignor to WAGNER BROTHERS, INC. *U.S. Pat.* 2,648,627.

Use of Lead-containing Undercoat in Nickel+Chromium Plating

Prior to electroplating with nickel, or nickel followed by chromium, a coating of lead or a lead alloy is deposited. The lead-containing layer may be copper-plated before electrodeposition of the nickel.

A. L. PEACH. *Brit. Pat.* 700,535.

Plated Anodes for Thermionic Valves

A thermionic valve anode comprises copper coated with a layer of nickel or rhodium, and finally with gold.

M. O. VALVE CO., LTD. and D. A. WRIGHT. *Brit. Pat.* 698,675.

Production of Copper-Clad Steel Plates

In producing copper-clad steel plates a layer of nickel is electrodeposited on one face of a plate of oxygen-free copper, the copper plate is secured to a steel slab or ingot with the nickel-plated surface in contact with the steel slab or ingot, and the composite assembly is heated throughout at about 1550°–1800°F. (840°–980°C.). The heated composite is rolled to reduce its thickness to ¼–1/25 of the original thickness, with the proviso that reduction in thickness per pass is not more than 1/8-in.

LUKENS STEEL CO. *Brit. Pat.* 699,067.

Cobalt Additions to Nickel-Copper Electrical-Resistance Alloys

An electrical-resistance element is made from an alloy containing copper 50–60, cobalt 1·5–2·5, per cent., balance nickel. It has a temperature coefficient of electrical resistance (over the temperature range 20°–100°C.) between $-3\cdot3\times10^{-5}$ and $+2\cdot3\times10^{-5}$. In the alloy containing copper 55, cobalt 2, per cent., balance nickel, the temperature coefficient of resistance is zero between 20° and 100°C.

BRITISH DRIVER-HARRIS CO., LTD. *Brit. Pat.* 700,650.

Powder-Produced Heavy Alloys

Alloys of high density consist of a major proportion of tungsten and/or molybdenum (e.g., 95–99 per cent.), and a small amount of nickel (e.g., 1–3·5 per cent.), with or without copper, which is preferably not more than half the nickel content. The alloys are made by compacting a mixture of the constituent metal powders and subsequently sintering the compact at 1400°–1600°C., the intermixing of the powders being such that each particle of tungsten and/or molybdenum is substantially surrounded by nickel (and copper if present).

GENERAL ELECTRIC CO., LTD. and W. R. PITKIN. *Brit. Pat.* 699,916.

Powder Production of Nickel-Magnesium Alloys

A metal powder or a mixture of two or more metal powders is pressed to form a compact, and while the compact is in a confined space it is heated in contact with the vapour or vapours of one or more volatile metals or metallic compounds, and the product is sintered. An example relates to a nickel-magnesium alloy (1 per cent. magnesium) made from compacted and degassed carbonyl-nickel powder and magnesium vapour. The method is particularly suitable for making α solid-solution-phase alloys and alloys in which crystal growth is restrained by the presence of inclusions.

GENERAL ELECTRIC CO., LTD. and K. JACKSON. *Brit. Pat.* 700,607.

Hot-Pressing of Metal Powders

In production of shaped articles by powder-metallurgy technique the powders are mixed with substances which give off neutral or reducing gases at or below the hot-pressing temperatures, and the powders are

pressed to shape at 100°–800°C. (preferably at 200°–500°C.) after gas evolution has ceased. The procedure may be applied to silver–nickel alloys.
METRO-CUTANIT, LTD. *Brit. Pat.* 700,658.

Production of Ferrites viâ Metal Carbonyls

Ferrite powders are formed by burning a vaporized mixture of the carbonyls of iron and at least one other carbonyl-forming metal in an oxygen-containing gas, preferably with excess of oxygen. The method is mainly directed to production of $NiO.Fe_2O_3$ and $CoO.Fe_2O_3$, but the use of the carbonyls of chromium, tungsten, molybdenum and ruthenium is also mentioned.
GENERAL ANILINE AND FILM CORPN. *Brit. Pat.* 697,059.

Hardening Treatment for Nickel-Alloy Cast Iron

Austenitic iron castings are hardened by heating at 1600°–1800°F. (870°–980°C.) and slowly cooling to below 900°F. (480°C), i.e., at an average rate not exceeding 50°F. (28°C.) per hour.

Castings suitable for such treatment contain total carbon 2·5–3·25, nickel 7–9, copper 3–4·5, per cent. (the sum of the nickel and copper being 10–12 per cent.), chromium 1–4, silicon 1·5–3, manganese 0·3–1, per cent., balance essentially iron. A hardness of at least 450 Brinell can be produced by the specified treatment.
F. G. SEFING, assignor to INTERNATIONAL NICKEL CO., INC. *U.S. Pat.* 2,646,375.

High-Yield-Strength Nickel-Alloy Steels

A low-alloy steel of high yield strength is characterized by showing, as-rolled and normalized (in sections up to about 1 inch), a minimum yield strength, at 0·2 per cent. offset, of 90,000 p.s.i. (40 tons per sq. in.). The steel contains carbon 0·05–0·15, silicon 0·9–2, manganese 1–2, nickel 1·5–2·5, chromium 0·14–1·2, molybdenum 0·05–0·6, copper 0·2–0·6, sulphur and phosphorus each 0·05 max., per cent., balance iron.
P. PAYSON and A. E. NEHRENBERG, assignors to CRUCIBLE STEEL CO. OF AMERICA. *U.S. Pat.* 2,634,205.

Creep-Resisting Steels

Austenitic steels for high-temperature applications contain carbon up to 1, silicon up to 1, manganese up to 2, nickel 10–16, chromium 12–24, tungsten 0·7–2, molybdenum 1·5–4, vanadium 0·7–2, boron 0–0·1, per cent., iron balance. Preferred compositions are given.
WM. JESSOP AND SONS, LTD., G. T. HARRIS and H. C. CHILD. *Brit. Pat.* 700,246.

Heat-Treatment of High-Temperature Materials

Heat-resisting steels and nickel-base alloys (particularly in the form of turbine blades) are heat-treated in a molten bath of boric acid or anhydride, and cryolite. The bath preferably contains 85–95 per cent. boric anhydride and 15–5 per cent. cryolite. Typical compositions of precipitation-hardenable materials suitable for such treatment are given.
ROLLS-ROYCE, LTD. (inventor, E. J. WHITEHEAD). *Brit. Pat.* 698,425.

Procedure and Equipment for Hot Pressing

In hot-pressing articles such as turbine or compressor blades between dies the temperature of the material to be shaped is raised to its forging-temperature range by contact with induction-heated dies, and electrical input is regulated by thermo-sensitive heads in the region of the die surfaces. The dies are preferably made from chromium-nickel austenitic steel, cobalt-base alloys containing tungsten, or nickel-chromium alloys, having a creep strength, in the working temperature range (750°–850°C.), of about 8–15 tons per square inch.
J. A. HERON. *Brit. Pat.* 699,687.

Electropolishing of High-Alloy Materials

The electrolyte specified in *Brit. Pat.* 622,118*, comprising sulphuric acid or sulphuric acid + phosphoric acid, to which is added a small amount of an aromatic amino compound or compounds (e.g., aniline), can be used at temperatures between 20° and 90°C. for electropolishing not only stainless steels, but also chromium metal, chromium-iron alloys, alloys containing large amounts of chromium and nickel (with or without iron), and alloys containing chromium and nickel together with one or more of the elements cobalt, aluminium, titanium, manganese.
ELECTROPOL, LTD. and P. A. CHARLESWORTH. *Brit. Pat.* 699,013.

Nickel-base Alloy Resistant to Attack by Lead Compounds

A heat-resisting alloy capable of withstanding attack by lead-containing atmospheres at high temperatures contains chromium 15–17, titanium 2·75–3·35, carbon 0·10 max., silicon 0·15 max., manganese 1·0–2·5, iron 8 max., per cent., nickel balance. A preferred composition is given. Such alloys are suitable, for example, for internal-combustion-engine valves.
MOND NICKEL CO., LTD. *Brit. Pat.* 698,299.

Complex High-Alloy Welding Rod for Hard Facing

A welding rod for hard facing comprises a ferrous metal tube containing, in specified amounts, (1) a finely divided mixture of titanium carbide, boron carbide and/or boron oxide, nickel and manganese; (2) optionally, chromium, iron; carbides of titanium, zirconium, tantalum, niobium, boron, vanadium, chromium, and tungsten; and zirconium, tantalum, niobium, boron, vanadium, and titanium in metallic form. The preferred flux contains limestone, barium carbonate, calcium fluoride, graphite and potassium silicate within specified limits.
L. NUSSBAUM. *Brit. Pat.* 699,646.

* See *Nickel Bulletin*, 1949, vol. 22, No. 10, p. 168.

Attention is drawn to the fact that many of the names of materials mentioned in The Nickel Bulletin are *Registered Trade Marks.*

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